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AR DEPARTMENT TECHNICAL MANUAL

U.S. Dept. of Army

COMPASS, SUN

UNIVERSAL TYPE,

ABRAMS MODEL SC-1

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By order of the Secretary of War:

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Chief of Staff.

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Major General,
The Adjutant General.

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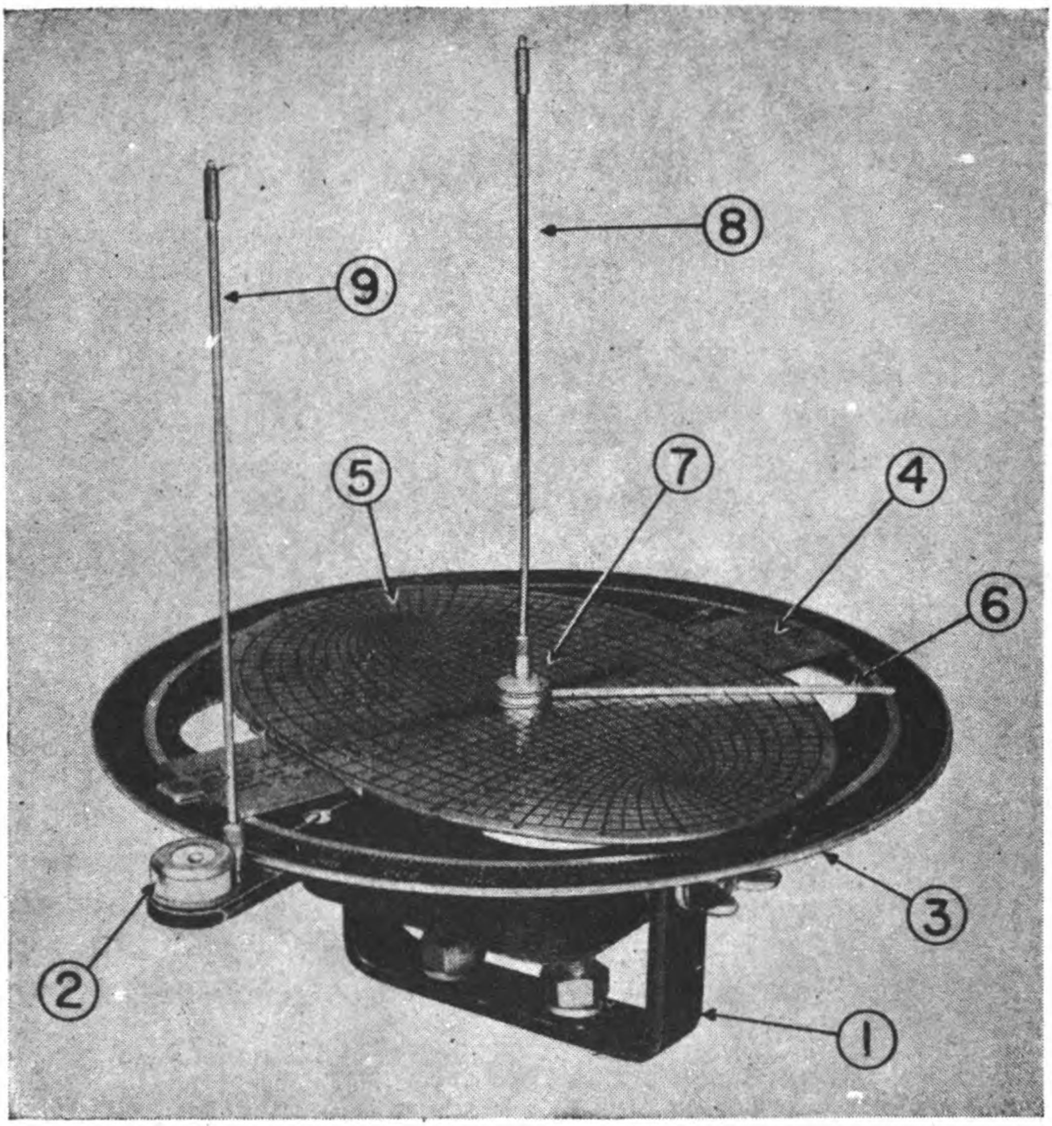


FIGURE 1.—The Universal Sun Compass.

1. Gimbal mounting
2. Level vial
3. Protractor plate
4. Date bar
5. Solar plate
6. Shadow bar
7. Pivot bolt
8. Gnomon rod
9. Sighting rod

SECTION I

INTRODUCTION

1. This manual is a Handbook of Instructions with a parts list for the Universal Sun Compass Model SC-1, a direction instrument for land navigation.

a. This Handbook contains descriptive data and instructions for the installation, operation, maintenance, and disassembly and assembly of the Sun Compass.

b. The Parts List contains a group assembly parts list arranged and intended to show the relationship of single parts to sub-assemblies and of the sub-assemblies to the main assembly. Column 1 contains a list of key numbers by which each part is designated on the accompanying exploded view of the instrument. Column 2 is the manufacturers part number by which each part and sub-assemblies may be procured. Column 3 is the part name with descriptive information on standard commercial parts. Column 4 indicates the number of parts in a sub-assembly, and the number of sub-assemblies in the main assembly. When a part number is preceded by an asterisk (*), this indicates that the part is procurable in the assembly only.

SECTION II

DESCRIPTION

1. GENERAL DESCRIPTION.

a. The Universal Sun Compass is a mechanical device which utilizes the azimuth of the sun to obtain true direction. The instrument is ruggedly built and can be used on any type of vehicle on which it can be mounted properly.

b. The sun compass has many definite advantages over the magnetic compass. It is more rugged than the magnetic compass. The sun compass is not affected by any local magnetic attraction such as electrical circuits or metal as is the case with the magnetic compass. It is a very accurate direction instrument and has long been used to correct errors due to deviation of magnetic compasses. The sun compass can only be used when the sun is shining, or by sighting on the north

star at night when it is not cloudy. So it is the complement of, and does not replace the magnetic compass. The land navigator must be equipped with both, using the sun compass whenever possible, and reserving the magnetic compass for cloudy periods.

c. The sun compass is attached to the vehicle by means of a universal gimbal mounting (figure 1, item 1) which allows tipping the instrument in any direction to make it level. A level vial (item 2) attached to the extended arm of the gimbal mounting indicates when the instrument is level. A circular protractor plate (item 3) is secured to the gimbal mounting. A date bar (item 4), an oval shaped solar plate (item 5), and a shadow bar (item 6) are mounted successively on top of the protractor plate. A pivot bolt (item 7) acts as a pivot for these parts. The date bar can be rotated a full 360 degrees to any desired setting on the protractor. The solar plate can be slid along the date bar to the proper date mark. The shadow bar can be rotated a full 360 degrees over the surface of the solar plate to the proper time-latitude setting. The solar plate and the date bar are clamped at the desired settings by a star-shaped clamping nut on the lower end of the pivot bolt. A vertical gnomon rod (item 8) is mounted in the center of the pivot bolt. It casts a shadow which falls on the shadow bar when the proper adjustments have been made. This gnomon rod is used in conjunction with a sighting rod (item 9) on the gimbal mounting arm, to obtain a foresight or to sight on a star.

2. Detailed Description.

a. Gimbal Mounting.—The gimbal mounting (figure 1, item 1) frictionally prevents the compass from tilting, but allows it to be readily leveled. The holes provided for the mounting bolts in the bottom support of the gimbal mounting are made slightly oversize to provide an adjustment in aligning the compass parallel to the centerline of the vehicle. Wing nuts on the pivot bolts of the support can be tightened to rigidly secure mounting after it has been leveled.

b. Level Vial.—The level vial (item 2) is a round, heat resistant glass vial, enclosed in a metal cap and mounted on the Gimbal arm. It provides a ready means for leveling the com-

pass. A spare level is provided with each instrument in case of breakage.

c. Protractor Plate.—The protractor plate (item 3) is a round steel plate fastened to the gimbal mounting and marked off in one degree intervals numbered every ten degrees, and so arranged to be read in a counter-clockwise direction. A line on the 180 degree to 0 degree diameter of the protractor plate must be parallel to the center-line of the vehicle, with the arrowhead pointing in the direction of travel. The protractor is used in setting the azimuth of a pre-determined course, or for determining in which direction the vehicle is traveling.

d. Date Bar.

(1) The date bar (item 4) is a flat steel bar mounted at its center on the pivot bolt. The solar plate can be moved along the date bar. The date bar has a center line terminating in an arrowhead by which the azimuth is set on the protractor. In operation, the arrow points true north if all settings on the instrument have been correctly made.

(2) There are a series of date lines engraved on the date bar, which represent the 10th, 20th, and last day of each month. These date lines indicate the proper position for the outside edges of the solar plate. Adjustment of the edge of the solar plate in between the lines can be made for intermediate dates. This setting compensates for the changing angle of the sun's rays to the earth, as the altitude of the sun changes from day to day.

FIGURE 2—The Date Bar.

(3) Along the outer edges of the date bar, there are a series of numbers. These numbers represent the equation of time or the amount of time in minutes to be added or subtracted from the mean solar time (the time at that instant on the time

meridian) according to the indicated sign, plus or minus, to obtain apparent or true sun time. Each number is directly opposite one end of a heavy line. The lines are opposite the date lines which represent the date to which the correction is applied. Intermediate values are obtained by adjustment within the length of the line. For a part of the months of December and January, the equation factors are given separately opposite the appropriate date. The date bar is made for the year 1943; however, the equation of time factors do not vary more than a few seconds from year to year.

***e. Solar Plate.*—The solar plate (item 5) is an oval-shaped plate mounted so that it will slide on the date bar. It has marked on its surface a series of elipses, one for each third degree of latitude starting at the equator and running each way to the north and south 45th latitude lines. These are crossed by a series of hyperbolas which represent local apparent time (true sun time) from 6 a. m. to 6 p. m. by quarter hour intervals. The order of the hour numbers is reversed in the north and south latitudes. The solar plate indicates where to set the shadow bar for any given time-latitude setting.**

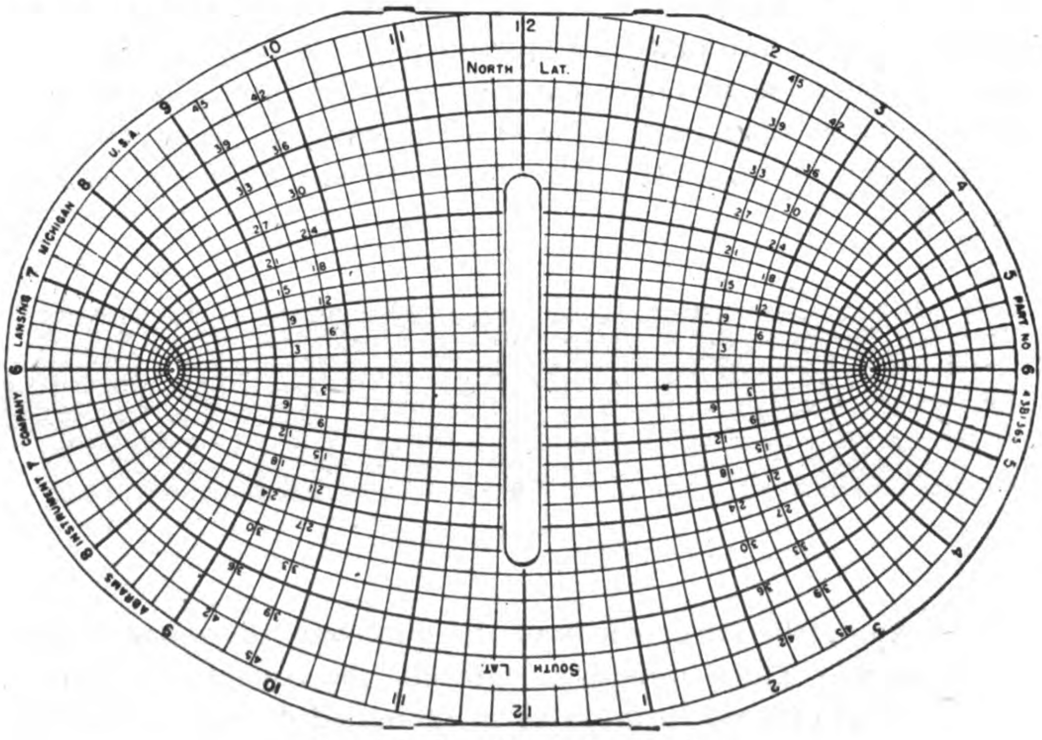


FIGURE 3—The Solar Plate.

f. Shadow Bar.—The shadow bar (item 6) is a straight, narrow bar pivoted on the shadow bar bearing on the pivot bolt. It determines where the shadow cast by the gnomon rod should fall when it is turned to the proper intersection of time and latitude lines on the solar plate. A special shadow bar washer exerts a pressure on the shadow bar, tending to hold it in the position at which it is set.

g. Gnomon Rod.—The gnomon rod (item 8) is a straight slender rod 6 inches long. It is screwed into the head of the pivot bolt. Its purpose is to cast a narrow shadow line on the solar plate. It is equipped with a radium tip to obtain bearings at night.

h. Sighting Rod. (Polaris)—The sighting rod used when sighting on Polaris (north star) is a slender rod, 3 inches long, which screws into the end of the date bar opposite the arrowhead. It also has a radium tip for use at night. It is shorter than the gnomon rod so that Polaris can be easily sighted in the higher latitudes.

i. Sighting Rod. (foresights)—The sighting rod (item 9) is used to obtain a foresight on a distant object and is a duplicate of the Gnomon rod. It is screwed into a hole in the gimbal arm near the level vial.

j. Clamping Nut.—The clamping nut is a large, star-shaped nut which screws on the lower end of the pivot bolt. It is used to clamp the solar plate and date bar in place after all settings have been correctly made.

k. Carrying Case.—A carrying case is provided in which to store and transport the sun compass when it is not in use. Only the gnomon and sighting rods need be disassembled from the instrument to place it in the case.

Section III

INSTALLATION

1. Mounting.

a. The sun compass must be mounted away from shaded portions of the vehicle where the sunlight will fall on it at all times and in such a position that the driver or his assistant can see the shadow cast on the solar plate by the gnomon rod.

On a tank, it should be mounted outside the turret where the tank commander can observe it when the hatch is open.

b. **A bracket made of $\frac{3}{8}$ in. x 2 in. strap iron, which can be bolted to an appropriate place on the vehicle, provides a suitable mount for the compass.**

c. **The compass must be mounted so that the 0-180 degree line on the protractor is parallel to the center-line of the vehicle, with the arrowhead at the 0 degree mark pointing in the direction of the forward travel of the vehicle. It is fastened securely to the mounting bracket, or directly to the vehicle, by two bolts. If a bracket is used, this furnishes a means of permanently aligning the compass parallel to the center line of the vehicle (see paragraph *d*). Unless the compass mount is permanently marked for alignment, it must be realigned if it becomes necessary to remove the compass for any reason.**

d. A method of mounting and aligning the compass using a mounting bracket follows:

(1) Select a mounting position where the compass is readily accessible to the operator and where sunlight will fall unobstructed on its surface.

(2) Install the strap iron mounting bracket perpendicular to the center line of the vehicle.

(3) Drill two $\frac{13}{32}$ in. diameter holes spaced 1$\frac{1}{2}$ inches, center to center, in the mounting bracket, approximately perpendicular to the center line of the vehicle. There is only $\frac{1}{32}$ adjustment due to enlarged holes in the compass lower support member so that a line connecting the centers of these two holes must be very nearly perpendicular to the center line of the vehicle.

(4) Secure the compass lower support member to the mounting bracket with one bolt, so that the arrow on the protractor points in the direction of forward travel.

(5) Measure the distance (C-B, figure 4) from the center of the vehicle to the center of the compass.

(6) At some point (at least 6 feet ahead of the vehicle) again determine the center of the vehicle (point D).

(7) Mark off the distance C-B at point D perpendicular to the center line of the vehicle (line C-D). This determines point A.

(8) Stretch a string from point A to the center of the compass (point B).

(9) Turn the compass until the string is directly over the "0" degree mark on the protractor. CAUTION: Be sure the string is tight and not thrown out of line by any object.

(10) Insert the second bolt and tighten them both securely. Recheck the alignment.

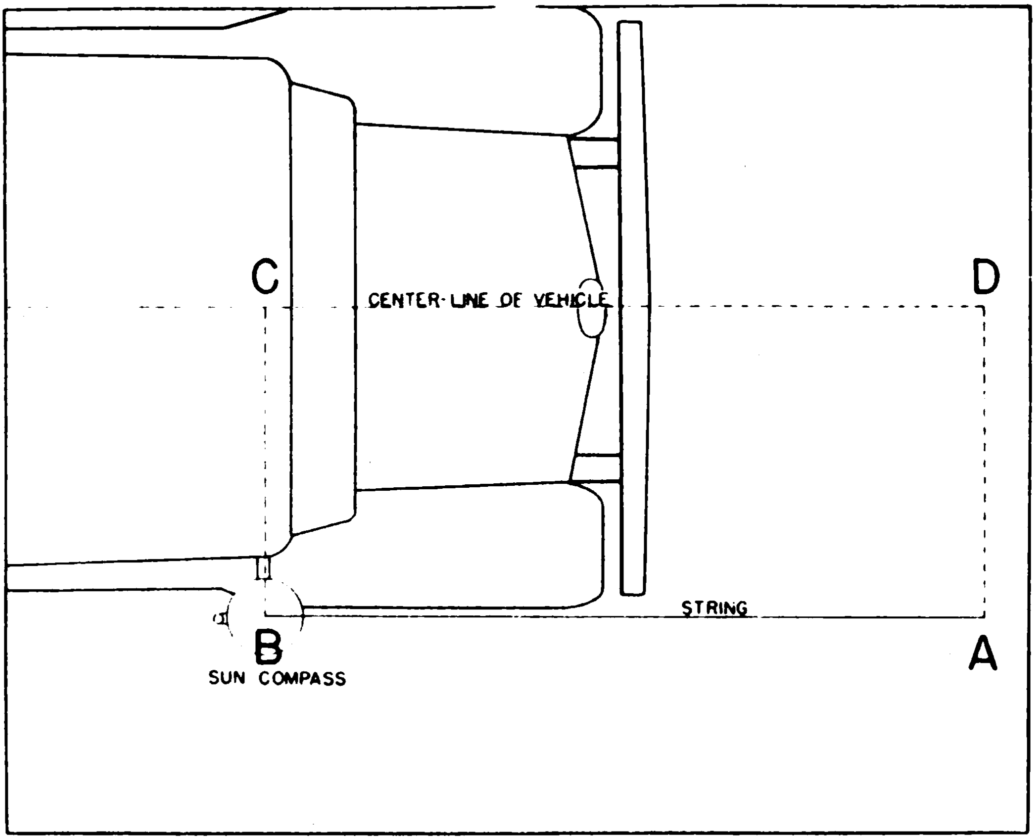


FIGURE 4—Mounting Diagram.

(11) After the compass is completely aligned, mark a line on the mounting bracket, using one edge of the lower support as a guide. This mark will be used as a guide to realign the compass in reinstallation, if it should be removed.

(12) When not in use, the sun compass is stored in a carrying case provided. Only the gnomon and sighting rods need be disassembled to place the compass in the case.

SECTION IV.

OPERATION

1. **CONVERTING WATCH TIME TO SUN TIME (Apparent Time).**

a. General.—Because the operating principle of the sun compass is based on determining direction from the shadow cast by the sun, the time piece used must be set and maintained on sun time. Sun time, called apparent time, is based on the movement of the sun which is found to be irregular throughout the year while watch time is based on a standardized system of regular time adopted by the countries of the world for convenience's sake. To convert local watch time to local apparent time (local sun time) it is necessary to perform a series of time changes and to fully understand the terms applied to them.

b. Standard Time.

(1) A system of time called "standard time" has been adopted by nearly all nations of the civilized world. The world has been divided into 24 imaginary longitudinal sections called time zones (see figure 6), each zone representing one hour of the 24 hour day. Theoretically, these zones should be of the same size and shape. However, referring to figure 6 we see that due to political division, some zones have very irregular boundaries and have adopted times which are not standard for the zone in which they theoretically should lie.

(2) The system of standard time was developed by taking Greenwich, England as the prime meridian and establishing 24 different time meridians around the world, 15 degrees of longitude apart, so that, standard times in zones would agree with Greenwich in minutes and seconds but differ in hours by whole numbers. That is, when it is 12:20 A.M. in Greenwich, it is 1:20 A.M. in a city in the next time zone east. All the clocks in a time zone are set to agree with the time based on the time meridian in the center of that zone. This is true if the people within the zone have not adopted a different time for economic reasons.

c. Changing from Fast to Standard Time.

(1) It happens that in many cases, for reasons of saving daylight hours, many countries or zones within a country have adopted the standard time of the zone to the east of them.

That is, by setting clocks at 12 o'clock noon when it is 11 o'clock by standard time. Sunrise and sunset can be made to come one hour later by the clock. This time may be called "Daylight Saving Time", "Wartime", or "Fast Time", and is usually adopted during the summer months.

(2) The first step in changing from local watch time to local apparent time (sun time) is to change the local watch time to standard time. Determine from military or civil sources the time at which local clocks are set and adjust the watch used with the sun compass to standard time.

d. Mean Solar Time.

(1) The standard system of time is based on mean solar time. The real sun has an apparent motion around the earth which due to the travel of the earth along its orbit, is non-uniform from day to day. Ordinary time pieces are not able to correct

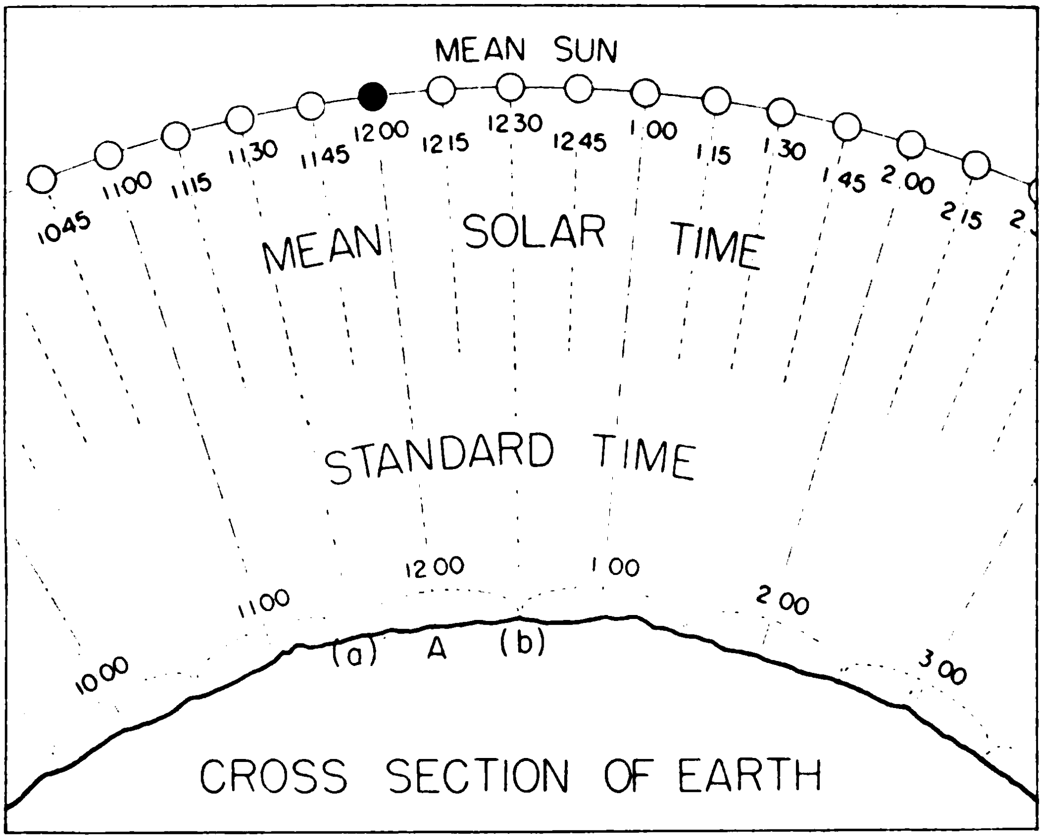


FIGURE 5—Comparison of Mean Solar Time and Standard Time.

for this irregularity. So, in order to get days of equal length, a *fictitious* or *mean* sun is assumed to revolve around the earth at a uniform rate. Mean solar time is time based on this mean sun. The real sun is either ahead of or behind the mean sun by a few minutes. For this reason, mean solar time (sometimes called civil time) cannot be directly determined by observation on the sun, but is a measure of time based on the fictitious mean sun. It is noon for a time zone according to the standard time system, when the fictitious mean sun is directly over a time meridian (see figure 5).

(2) The section of the earth's surface in figure 5 is divided into five standard time zones, represented by the dotted lines near the ground. Each of these zones uses as its standard time, the mean solar time of the meridian which passes through its center (such as point A, figure 5). Thus, for example, the clocks all through the zone (a) to (b) indicate 12 o'clock, when it is precisely noon by mean solar time at point A, although the mean solar time at points (a) and (b) may range from 11:30 o'clock to 12:30 o'clock.

e. Changing from Standard to Mean Solar Time.—The next step in changing the time piece from local watch time to local apparent time (sun time), is to change the time from the standard time of the zone to the mean solar time for the locality. If the locality is on the time meridian, the two times are the same. If it is not, the time must be corrected for the number of degrees in longitude that the locality lies east or west of the nearest time meridian. As a time zone is 15 degrees wide and represents one hour of time, each degree of longitude represents 4 minutes of time correction to be applied to standard time. If the locality lies east of the time meridian add the correction, if west, subtract it.

f. Equation of Time.—As was stated before, the real sun in its irregular apparent travel around the earth is either a few minutes ahead or behind the fictitious mean sun which has a uniform rate of travel. Four times a year the two suns coincide. The angular difference between the positions of the two suns at any time is referred to as the "equation of time", and is expressed in minutes of time. The equation of time is a measure of how much the real sun is ahead or behind the mean

sun. This factor is expressed in minutes on the date bar of the sun compass, opposite the appropriate date.

g. Changing Mean Solar Time to Local Apparent Time.

(1) When the equation of time is applied to the mean solar time for our position, the result is the local apparent time (true local sun time) for the position. The equation of time is expressed in minutes as a plus or minus factor according to the accompanying sign on the date bar. It should be added or subtracted to the mean solar time as the sign indicates. The time piece, after the equation of time is applied is now set at local apparent time and must be maintained at this time as long as it is used with the sun compass in any one locality.

(2) Actually, the entire conversion process from local watch time to local apparent time for a locality requires only a few seconds when the required data is available. The data required and an outline of the conversion process follows:

h. Outline of Time Conversion Process.

(1) Ascertain from military authorities that the timepiece to be used with the sun compass is keeping accurate time in accordance with the time adopted for use in this locality.

(a) Determine whether local time is the standard time for the zone in which the locality lies, or whether a fast or daylight saving time is used. If a fast time is used, ascertain the number of hours it is faster than the standard time, and correct the time piece to standard time.

It is possible to determine standard time by time signals sent out by many observatories either daily, hourly, or sometimes, continuously every second or every other second; to various parts of the world for the purpose of giving accurate time. They are sent out by radio or over telegraph or telephone wires.

(2) Determine your position (your local meridian) to the nearest degree from a map or from instruments.

(3) Locate the time meridian upon which local standard time is based (see figure 6).

(4) If your local meridian (your position) is east of the time meridian *add* four minutes for each degree to local standard time. To each degree west of the time meridian *subtract*

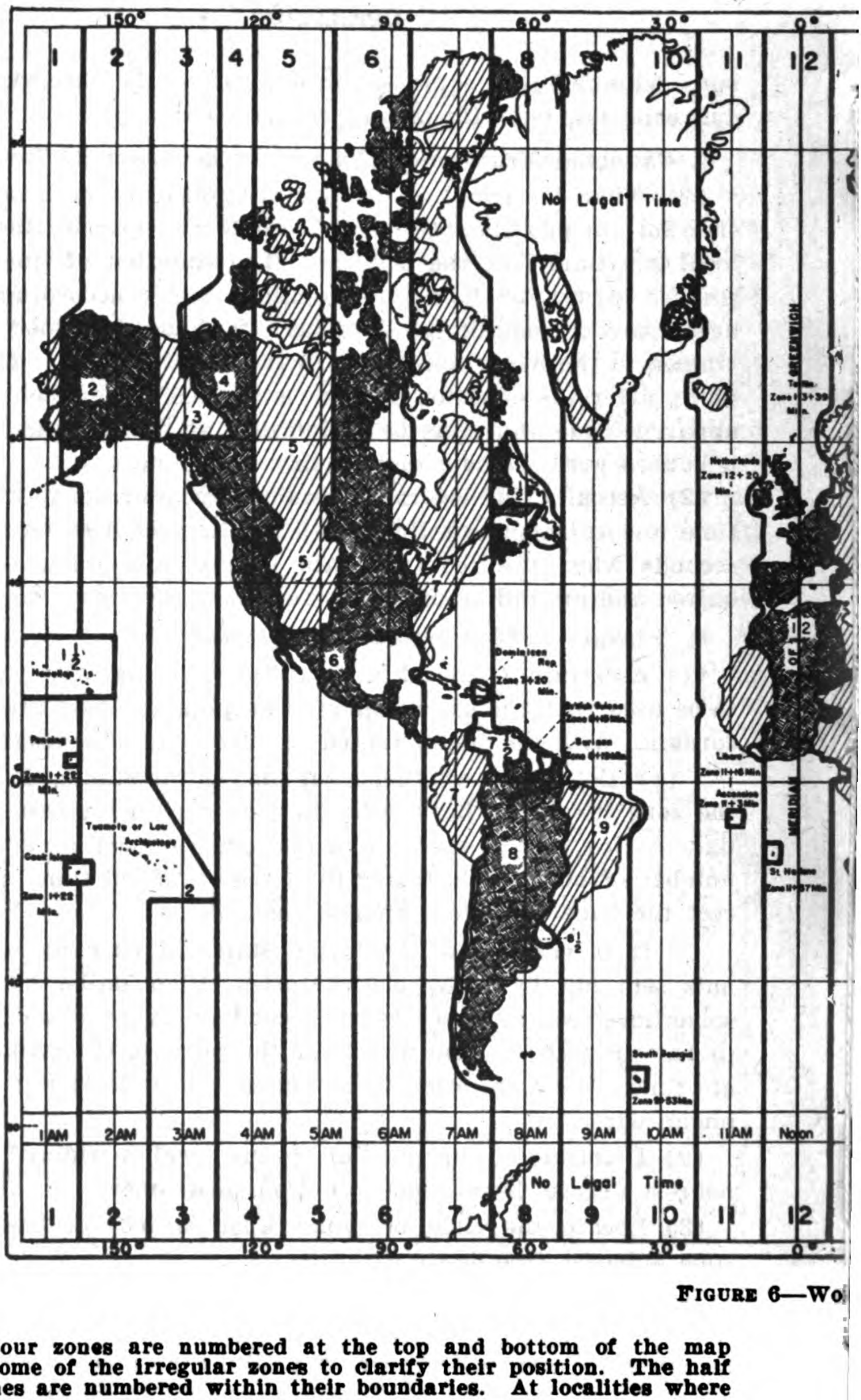
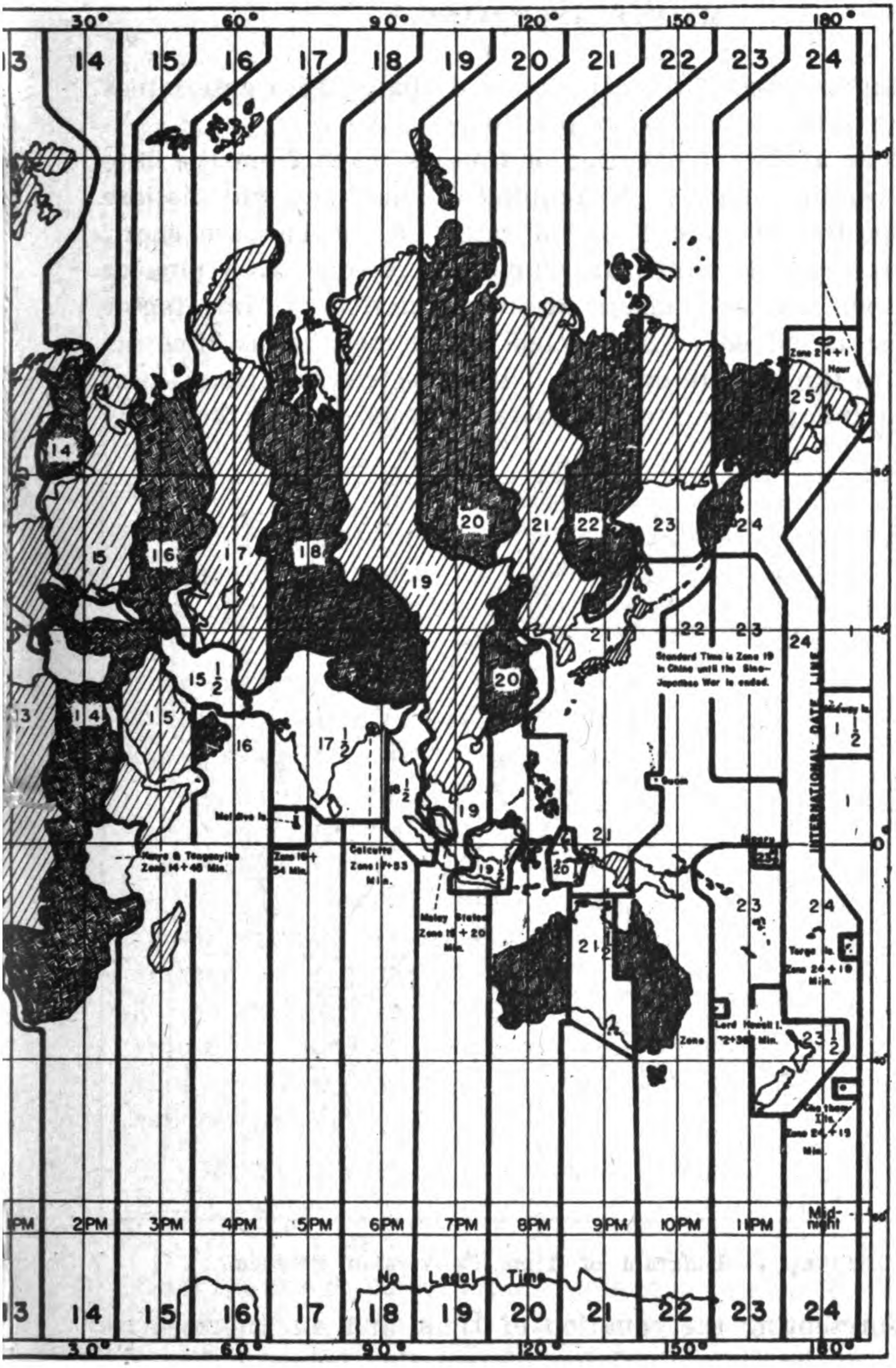


FIGURE 6—Wo

The hour zones are numbered at the top and bottom of the map and in some of the irregular zones to clarify their position. The half hour zones are numbered within their boundaries. At localities where



ld Time Zones.

neither the hour or half hour time is used, the time which serves as standard for that locality is given in the nearest convenient space.

four minutes from the local standard time. This determines the mean solar time at your position.

(5) Now apply the equation of time as taken from the date bar of the sun compass. Examining the date bar will disclose that opposite the date lines indicated on the bar are short, heavy lines beside which are numbers preceded by a plus or minus sign. These numbers are the equation of time factor and must be added or subtracted to the mean solar time according to the sign, in order to determine true sun time (local apparent time). There are numbers on each end of the heavy

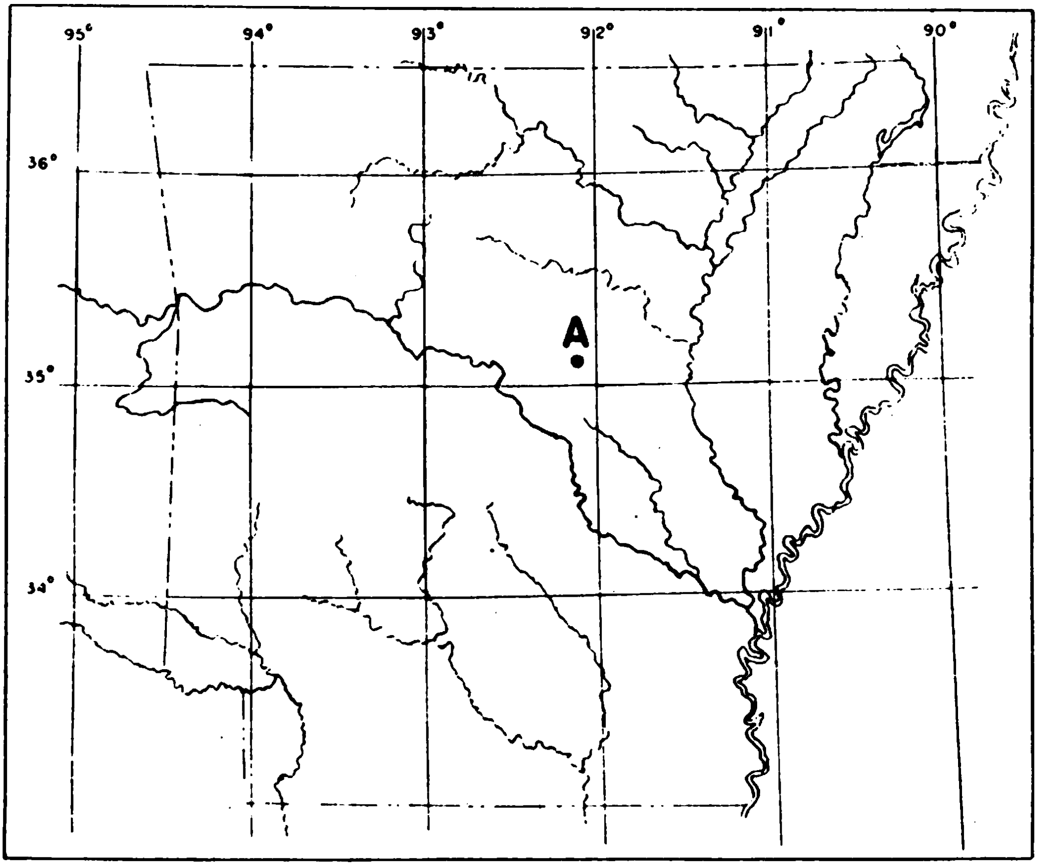


FIGURE 7—Diagram of Time Conversion Problem.

lines representing the equation of time, and an intermediate reading can be determined by interpolation between them.

(6) A sample conversion problem follows:

(a) Referring to figure 7 which is a section of a map embracing part of a time zone, we determine that our position

(point A) lies on the local meridian which is closest to the 92 degree longitude meridian.

(b) The date on which the problem is being worked is November 8, 1943, and the time which military authorities have furnished is 10:38 A.M. Wartime, which is one hour faster than standard time for this zone. The problem is worked as follows:

(*1*) Set the timepiece accurately to 10:38.

(*2*) Note the time 10:38 on a sheet of paper and subtract one hour to determine local standard time. The resulting time is 9:38 A.M. This is standard time throughout the zone.

(*3*) From the map we determine how many degrees east or west our location is from the true meridian for this zone. Our position is nearest the 92 degree longitude line and is 2 degrees west of the time meridian on the 90 degree longitude line. We must subtract 4 minutes for every degree we are west of the time meridian, so our correction is 4 x 2=8 minutes. This subtracted from 9:38 results in the time of 9:30, which is the mean solar time for our position.

(*4*) To complete the problem and find local apparent time, we must apply the time equation factor from the date bar to the time of 9:30.

(*a*) By observing the date bar, we see the equation of time factor opposite the date line which represents the 8th of November is a + 16 minutes.

(*b*) Adding the 16 minutes to the mean solar time of 9:30 results in the local apparent time of 9:46 A.M. This is the time to which we will set the timepiece to be used with the sun compass.

2. Determining Local Apparent Time Directly from the Sun Compass.

a. It is possible to determine local apparent time directly from the sun compass without referring to standard time if one can determine true north. It is not an accurate method of determining local apparent time and should be used only as an alternate method.

(1) To ascertain true north it is necessary to correct a magnetic compass reading for declination.

(a) This information is sometimes given on the map and included in the figure representing direction, such as that found in the "Compass rose." It can also be obtained from an isogonic chart which includes the locality in question. The isogonic chart is covered with continuous isogonic lines. Each isogonic line represents the number of degrees declination, east or west, that the compass needle bears from true north as it travels along an isogonic line. That is, at any point along an isogonic line, the compass needle will have the same declination from true north.

(b) This declination must be added or subtracted to the magnetic compass reading to determine a true north azimuth reading.

(2) Turn the date bar on the sun compass until the arrowhead points true north.

(3) Slide the solar plate along the date bar until the outside edges coincide with the date line on the date bar which represents the date of the day.

(4) We can now find the apparent time (sun time) for the locality by determining the time line indicated by the intersection of the shadow cast by the center gnomon rod and the latitude line which represents the latitude of the locality to the nearest degree. Follow the time line to the edge of the solar plate and read the time indicated. The time lines represent each hour of the day from 6 A.M. to 6 P.M. o'clock, broken down into quarter hours.

3. **Operation Instructions.**

a. General. The driver of the vehicle or his assistant may use the sun compass. If the assistant reads the compass and passes instructions on to the driver, a great deal of benefit will be derived from the teamwork between the two. This allows the driver to concentrate on maintaining the course.

The azimuth to be followed on a predetermined course is obtained from a map. NOTE: Magnetic or grid azimuths must be converted to true azimuths.

b. Operation Procedure.

(1) *Orienting the Vehicle to a Predetermined Azimuth.*

(a) Set the timepiece to be used with the sun compass to local apparent time (see paragraph 1, section IV).

(b) Loosen the clamping nut underneath the sun compass and turn the date bar until the arrow-head terminating the direction line points to the degree mark on the protractor which represents the azimuth of the course to be followed.

This azimuth is determined from a map, providing it has some direction line on it such as a north arrow or projection line. This is accomplished by laying a protractor on the map so that its center point coincides with your position and the edge is parallel to a true north and south line on the map. The destination point is marked on the map and a line drawn from it to your position. The clockwise angle formed between true north and the line drawn to the destination point from your position is the azimuth of the desired course. NOTE: The operator must be sure that the azimuth is read from true north.

(c) Slide the solar plate along the date bar until the straight outside edge coincides with the date line on the date bar which represents today's date. Both sides of the date bar are the same so that it does not matter which edge is used. Clamp the date bar and solar plate in position by turning up on the clamping nut.

(d) The shadow bar is rotated until it coincides with the intersection of the proper time and latitude lines.

The latitude will be taken from the map or instruments. The time is taken from the timepiece which is maintained on local apparent time.

(e) The compass is leveled by referring to the level vial and clamped. Then the vehicle is turned until the shadow cast by the center gnomon rod falls on the shadow bar. The vehicle is now headed on its course and the arrow-head on the date bar points to true north.

(f) As the vehicle proceeds along the course, the shadow bar should be reset to a new time at regular intervals of 15 minutes—the time being taken from the timepiece maintained on local apparent time.

If the course lies nearly east or west, on long fast journeys, the longitude will change enough to require a correction to the local apparent time maintained by the timepiece. (4 minutes correction for each degree of longitude) to be added

when traveling east and subtracted when traveling west. One degree of longitude is approximately 49 miles at 45 degrees latitude and approximately 69 miles at the equator.

(2) *To Determine an Unknown Azimuth.*

(a) If it is desired to know in what direction a vehicle is headed, the solar plate is adjusted to the proper date line on the date bar.

(b) Rotate the shadow bar to coincide with the intersection of the time and latitude lines which represent your latitude and time (according to local apparent time).

(c) Turn the date bar, solar plate, and shadow bar as one unit until the shadow cast by the center gnomon rod falls on the shadow bar.

(d) The arrowhead on the date bar is pointing to the degree mark on the protractor of the sun compass, which is the azimuth of the course on which the vehicle is headed.

(3) *Maintaining the Course by the Use of Foresights.*

(a) In order to keep on an accurate course of travel, foresights on distant objects located between the vehicle and the final destination should be taken as often as possible. The vehicle should be stopped, the compass leveled, and a sight made on a distant object by aligning the object and the sighting rod screwed into the gimbal arm, with the gnomon rod. This distant object is some object in the direct line of travel when the vehicle has been oriented on its course as explained in paragraph 3—b., section IV. The vehicle is steered in as direct a line as possible towards the selected distant object until it is reached; then a new reference point is selected and this procedure continued until the destination is reached. The vehicle must be stopped and the compass leveled for an accurate reading. Readings may be made when the vehicle is in motion by taking them at the instant when the compass is judged to be level. Deviations from a straight course, compulsory or otherwise, may be corrected for en route by changing the course of the vehicle until the amount of deviation has been overcome.

(b) In featureless terrain the vehicle is steered on a direct line of travel towards the final destination by constantly keeping the shadow of the gnomon rod in coincidence with the

shadow bar which has been properly set. It is impossible to make foresights because reference points are difficult to observe and maintain.

(4) *Using the Sun Compass at Night.*

(a) The sun compass may also be used at night by determining north from Polaris (north star). Figure 8 shows Polaris, the constellation "The Little Dipper" (Latin name—Ursa Minor, of which Polaris is the end star in the handle of the dipper), and two other constellations, the Great Dipper (Latin name—Ursa Major) and Cassiopeia. Ursa Major is called the Great Dipper because of the outline formed by its seven bright stars. A pair of these on the side of the bowl opposite the handle are called the "pointers" because a line connecting them, points at Polaris. Polaris lies about halfway between the constellations Ursa Major and Cassiopeia. All of these stars shown in figure 8 are easily recognized during any clear night by an observer north of the tropics.

(b) *Orienting the Vehicle to a Predetermined Azimuth.*

(*1*) Screw the three-inch radium tipped sighting rod into the hole provided in the date bar.

(*2*) Loosen the clamping nut and turn the date bar to the degree mark on the protractor which represents the predetermined azimuth.

(*3*) Turn the vehicle until Polaris is aligned with the short sighting rod and the gnomon rod. The vehicle is now headed on the right course.

(c) *Determining Unknown Azimuths.*

(*1*) Turn the date bar until the luminous tips of the sighting rod and the gnomon rod are in alignment with Polaris. The arrow on the date bar is now pointing approximately true north.

(*2*) The unknown azimuth in which the vehicle is headed is taken from the protractor. The arrow on the date bar points to the degree mark which represents the azimuth.

(d) *Using Stars as Foresights.*

Stars near the horizon may be used as foresights. However, these stars move and the azimuth should be checked by Polaris at intervals of 15 minutes.

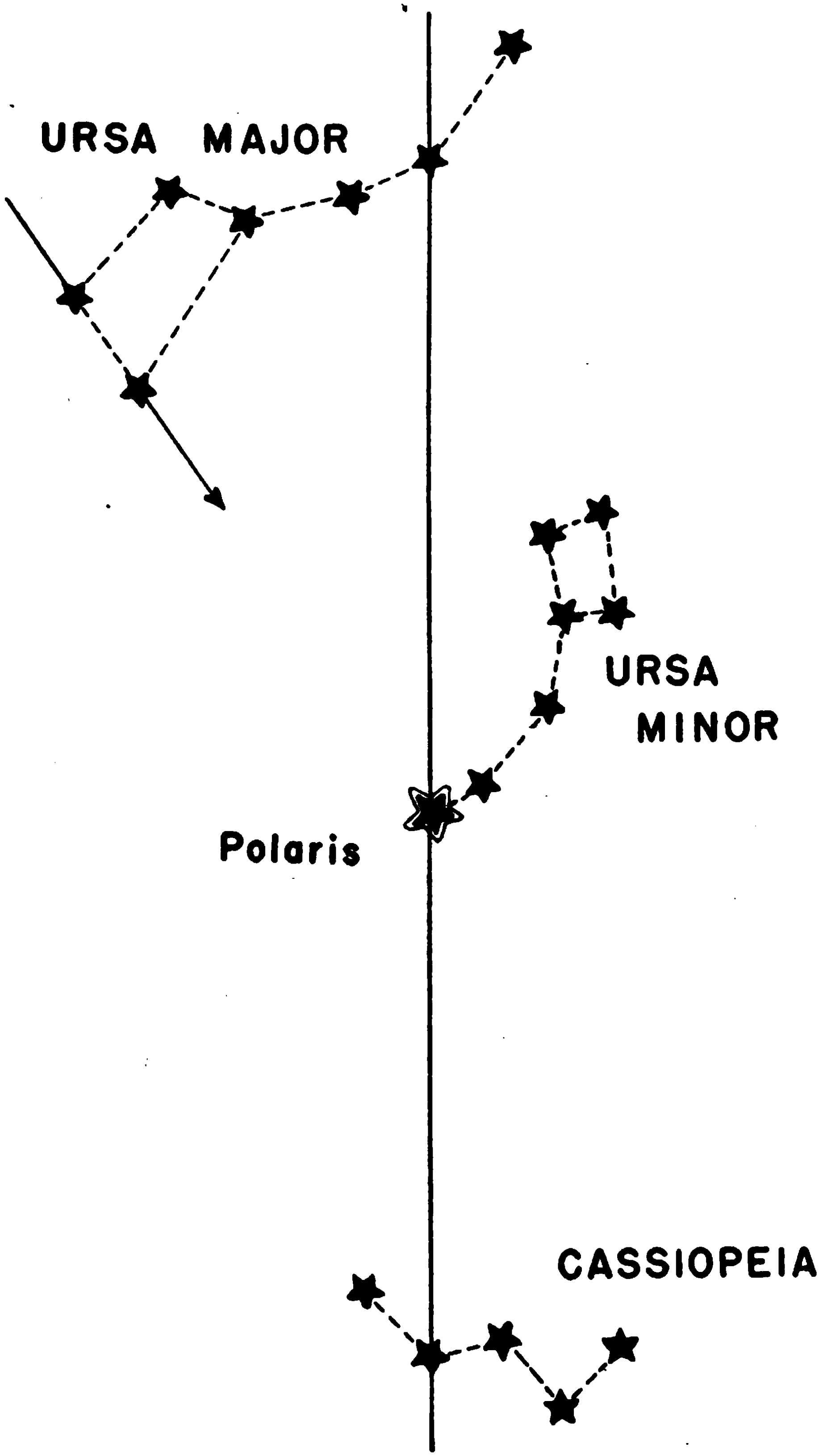


FIGURE 8—Location of Polaris.

(5) *Using the Sun Compass before 6 A.M. and after 6 P.M.* The sun compass can be used during the hours of sunlight before 6 A.M. and after 6 P.M.; however, it is necessary to make a mental change beyond the 6 o'clock positions in the numbers representing the hours on the solar plate. That is, the numbers should progress from 6 P.M. to 7, 8, etc. and from 6 A.M. to 5, 4, 3, etc. The numbers are reversed at the 6 o'clock position so that the solar plate will apply to both north and south latitudes.

Section V

INSPECTION AND MAINTENANCE

1. Inspection.

a. The instrument should be periodically inspected to determine the condition of the parts and to determine if any parts are missing.

b. Check the moving parts of the gimbal mounting for free movement and see that they can be securely clamped in a rigid position by turning up on the wing nuts.

c. Check the level vial and the etched surfaces of the protractor, date bar, and solar plate for legibility.

d. Check the gnomon rod, sighting rods, and shadow bar for straightness, and see that the luminous tips of the gnomon and sighting rods are not broken.

2. Maintenance.

a. Very little maintenance is required for this instrument.

b. The parts are light and consequently should be handled with care. The gnomon and sighting rods should be carefully installed to prevent bending them.

c. The instrument should be kept clean at all times, for upon this depends its legibility and consequent usefulness. It should be properly packed away in the carrying case when not in use.

Section VI

DISASSEMBLY, INSPECTION, REPAIR, REASSEMBLY

1. Disassembly. (See Figure 9.)

a. Remove the Gnomon and sighting rod from the compass.

b. Unscrew the clamping nut (item 2) from the pivot bolt

(item 3)—being careful not to lose the star nut spring (item 1)—and remove, successively, the pivot bolt, shadow bar washer (item 6), shadow bar (item 5), and shadow bar bearing (item 4), the solar plate (item 7), and the date bar (item 8).

c. The level vial (item 12) is removed by unscrewing two screws (item 14) inserting through the gimbal arm (item 10), into the level vial casing. Remove the level vial and casing assembly and the level vial casing washer (item 13).

d. The protractor plate is secured to the gimbal arm and bearing assembly (item 11) by two flat-head screws (item 15), however, the protractor plate need not be removed to disassemble the instrument.

e. Unscrew the wing nut (item 23) from the hex-head bolt (item 20) which pivots and clamps the gimbal arm and bearing assembly in the frame and trunnion assembly (item 17). Remove the bolt, plain washer (item 22), lock washer (item 21) and slide the gimbal arm and bearing assembly out of the frame and trunnion assembly. Unless the cap screw lock (item 16) is damaged, it need not be removed.

f. To disassemble the support assembly, unscrew the two wing nuts (item 23) from the hex-head bolts (item 20) which pivot and clamp the frame and trunnion assembly to the support. Remove the bolts, plain washers (item 22) lock washers (item 21) and fibre washers, and lift the frame and trunnion assembly off the support (item 18). Again, unless the cap screw locks (item 16) are damaged, they need not be removed from the frame and trunnion assembly. This completes the disassembly of the Sun Compass Assembly.

2. INSPECTION.

Make an inspection of the parts as outlined in Section V.

3. REPAIR.

a. Repair of this instrument consists mainly of replacing any damaged or broken part.

b. If the gnomon or sighting rods are bent, carefully bend them back into a straight rod. If the luminous capsules are broken, replace the capsule and holder together as a unit, by unscrewing the holder from the rod and installing another holder and capsule.

c. If the level vial is broken, replace the level vial and casing assembly as a unit.

4. **Assembly.**

a. Place the frame and trunnion assembly (item 17) in the support (item 18), insert the hex-head bolts (item 20) with the heads inside the frame, seating the heads in the cap-screw locks (item 16) and placing the fibre washer (item 19) on the bolts between the support and frame and trunnion assembly. Place the lock washers (item 21) on the bolts next, then the plain washers (item 22) and screw the wing nuts (item 23) onto the bolts.

b. Place one end of the gimbal arm (item 10) and bearing assembly (item 11) on the small trunnion welded to the frame. Insert the hex-head bolt (item 20) through the other hole in the frame and gimbal arm with the head inside the frame, seating the head in the cap screw lock (item 16). Then install the lock washer (item 21), plain washer (item 22) and screw on the wing nut (item 23).

c. Secure the protractor plate (item 9) to the gimbal arm and bearing assembly, if removed, with two flat-head screws (item 15).

d. Place the shadow bar washer (item 6), shadow bar (item 5), and shadow bar bearing (item 4) on the pivot bolt (item 3) and after placing the solar plate (item 7) and date bar (item 8) on the protractor plate, line up the holes and insert the pivot bolt through the solar plate, date bar, and bearing on the gimbal arm.

e. Place the clamping nut spring (item 1) in the recess in the nut and screw the clamping nut (item 2) on the pivot bolt on the underside of the compass.

f. Screw the gnomon rod into the head of the pivot bolt and the sighting rod into the gimbal arm. This completes the reassembly of the sun compass.

SPARE PARTS

WAR DEPARTMENT
Q. M. C. Form No. 400
Revised Apr. 6, [illegible]

(SAMPLE)
REQUISITION

To: Engineer Field Maintenance Office — No. of Sheets 1 — Sheet No. 1
P.O. Box 1679, Columbus, Ohio

Requisition No. E-531-3-44 — Date 6 October 1943 — Period Special

SHIP TO Engineer Property Officer, Pine Camp, New York

MARKED FOR: Supply Officer, 147th Engineer Regiment, Pine Camp, New York

REQUISITIONED BY (show Signature, Rank, Organization, Destination. If different from "ship to" include address):

Robert E. Roe
Robert E. Roe
Major, C. E.
Engineer Property Officer

APPROVED BY:

John D. Doe
John D. Doe
Colonel, C. E.
Executive Officer

MFR. NO.	ARTICLES		Auth. or Max. Lev.	ON HAND	DUE IN	REQUIRED	APPROVED
	PARTS FOR COMPASS, SUN, UNIVERSAL TYPE SERIAL NO. 527						
	Basis: Repair of broken instrument.						
	Delivery requested by 20 October 1943.						
	GNOMON ROD						
43A1538	Luminous capsule assembly	ea.	-	0	0	1	
	LEVEL VIAL						
43A1387	Level vial assembly	ea.	-	0	0	1	
43A1400	Casing washer	ea.	-	0	0	1	

INSTRUCTIONS FOR PREPARATION OF REQUISITION

Space "TO."—To show the approving office to which requisition is submitted.

Space "PERIOD."—Show period for which the supplies are required.

Space "SHIP TO."—Full shipping address to be given. Where mail address is different from shipping address the former should also be shown, e.g., "Q. M., Fairfield Air Depot, Osborn, Ohio. Mail address, Fairfield." Except for established camps, posts, or stations, street or building address should be shown, e.g., "C. O. 328th Inf., National Guard, 456 Republic Bldg.. Grand Haven, Mich." Where the property is to be invoiced to an organization, etc., different from that to which it is to be shipped, the required information will be shown.

Space "STOCK NO."—Show stock number listed in Federal Stock Catalogue.

Space "ARTICLES."—Include sizes required. Show purpose numbers applicable to an article or group immediately above the article or group concerned.

Space "ON HAND AND DUE."—Show the quantity on hand plus the quantity approved on previous requisitions and not yet received.

Space "CONSUMED."—Show quantity consumed during the previous period.

Space "REQUIRED."—To be the quantity asked for by the requisitionist.

Space "APPROVED."—To be the quantity approved by the approving officer.

This form may be used in lieu of Q.M.C. Forms Nos. 402, 409, and 410 by appropriate modification.

IN THE SPACE BELOW SHOW BASIS FOR REQUISITION, i.e., Strength of Command, Number of Animals, Number of Animal-Drawn and Motorized Vehicles, Armament, or such other data as may be required by instructions issued by approving authorities.

THIS SPACE FOR ACTION OF APPROVING OFFICER

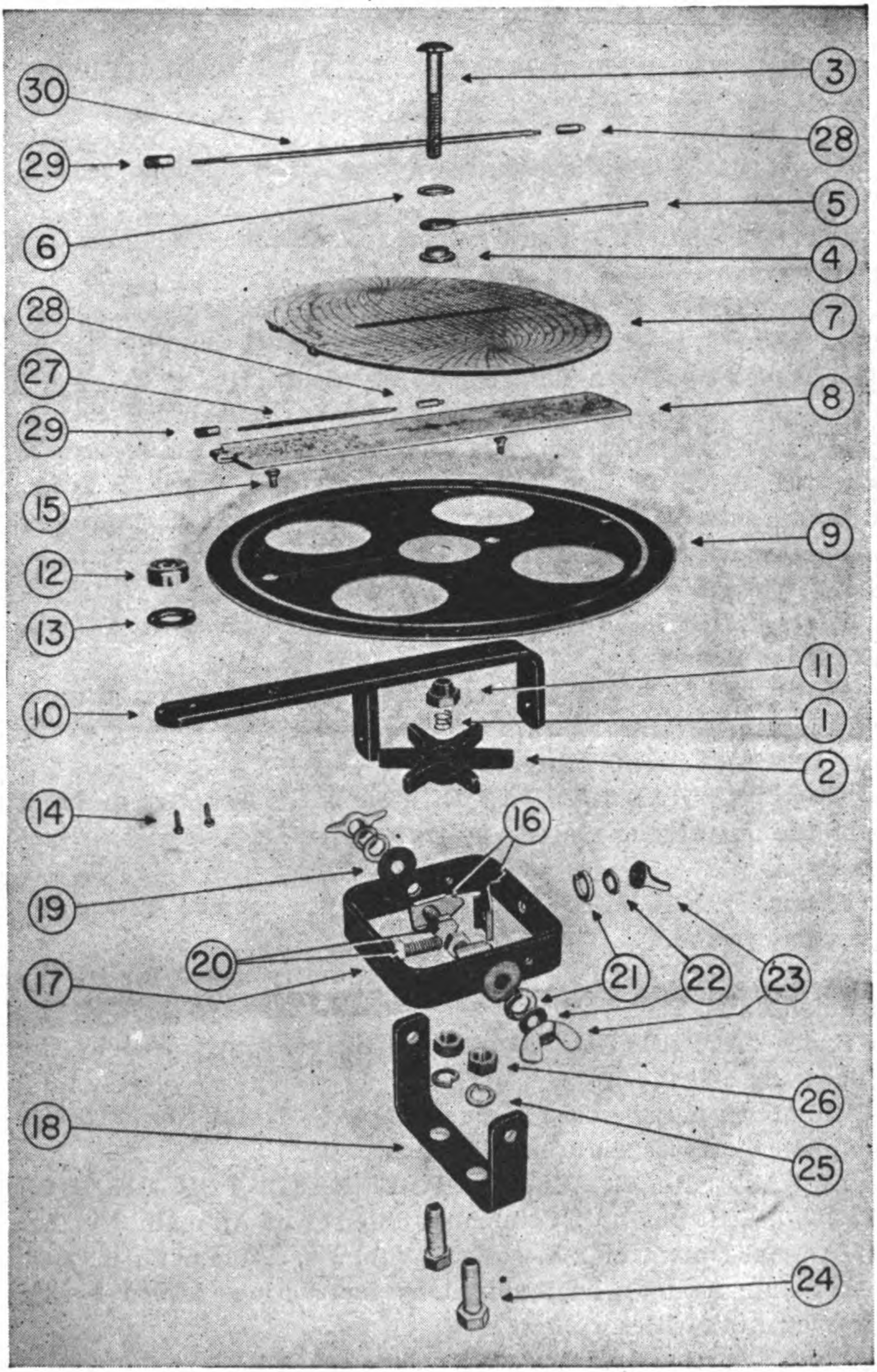


FIGURE 9—Detailed View of Sun Compass

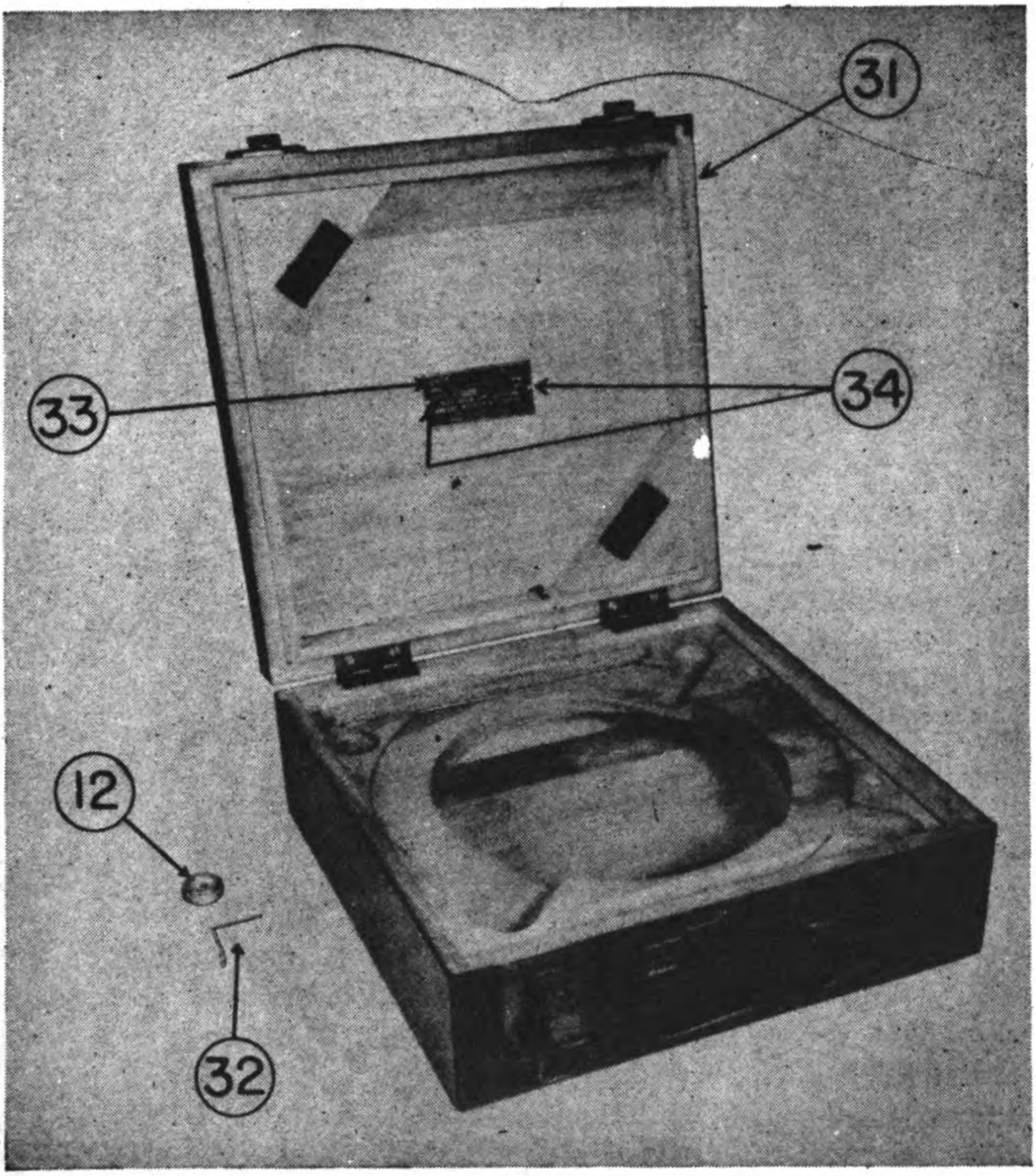


Figure 10—The Case and Accessories

GROUP ASSEMBLY PARTS LIST

Key No.	PART NO.	NOMENCLATURE	No. Req'd
	43D1360	SUN COMPASS ASSEMBLY	1
1	43A1361	Spring—Clamping nut	1
2	43A1368	Nut—Clamping	1
3	43A1367	Bolt—Pivot	1
4	43A1362	Bearing—Shadow bar	1
5	43A1404	Bar—Shadow	1
6	43A1363	Washer—Shadow bar	1
7	43B1365	Plate—Solar	1
8	43B1405	Bar—Date	1
	43C1385	PROTRACTOR PLATE SUB-ASSEMBLY	1
9	43C1370	Plate—Protractor	1
	43B1384	GIMBAL ARM, BEARING & LEVEL SUB-ASSEMBLY	1
10	43B1364	GIMBAL ARM ASSEMBLY	1
	*43A1375	Post—Gimbal arm	1
	*43B1374	Base—Gimbal arm	1
11	43A1369	BEARING BOSS ASSEMBLY	1
	*43A1379	Screw—Bearing Boss	1
	*43A1380	Key—Bearing boss	1
12	43A1387	LEVEL VIAL ASSEMBLY	2
	*43A1418	Vial—Level	2
	*43A1403	Casing—Level vial	2
13	43A1400	Washer—Casing	1
14	43A1427	Screw—Steel, R.H., Cad. Plated 2-56NC2—⅜ lgth (com'l)	2
15	43A1428	Screw—Steel, Cad. plated, F.H. 6 x 4 ONF—2 x ¼ lgth (com'l)	2
	43B1389	SUPPORT ASSEMBLY	1
16	43A1396	Lock—Cap screw	2
17	43B1383	FRAME AND TRUNNION SUB-ASSEMBLY	1
	*43B1401	Frame	1
	*43A1366	Trunnion—Frame	1
18	43B1402	Support	1
19	43A1406	Washer—Fibre	2
20	43A1429	Bolt—Hex hd, Cad. plated, 5/16-24NF-2 x ⅞ lgth (com'l)	2

* Part is procurable in the assembly only.

PARTS LIST

Key No.	PART NO.	NOMENCLATURE	No. Req'd
21	43A1431	Washer—Lock, Cad. plated, 5/16 (com'l)	2
22	43A1433	Washer—Flat, Cad. plated, 5/16 (com'l)	2
23	43A1434	Nut—Wing cad. plated, 5/16-24NF2 (Com'l)	2
24	43A1430	Bolt—Hex., cad. plated, H.D. 3/8-24NF-2 x 1 1/4 lgth (com'l)	2
25	43A1432	Washer—Lock, Cad. plated 3/8 (com'l)	2
26	43A1435	Nut—Hex., cad. plated, 3/8-24NF-2 (com'l)	2
	43A1371	GNOMON ROD ASSEMBLY—SMALL	1
27	43A1378	Rod—Gnomon, small	1
28	43A1538	LUMINOUS CAPSULE ASSEMBLY	1
	*43A1377	Holder—Capsule	1
	*43A1382	Capsule—Luminous	1
29	43A1376	Base—Gnomon	1
	43A1372	GNOMON ROD ASSEMBLY—LONG	3
30	43A1381	Rod—Gnomon, long	3
28	43A1538	LUMINOUS CAPSULE ASSEMBLY	1
	*43A1377	Holder—Capsule	3
	*43A1382	Capsule—Luminous	1
29	43A1376	Base—Gnomon	3
20	43A1429	Bolt—Hex. hd. Cad. plated, 5/16-25NF-2 x 7/8 lgth (com'l)	1
23	43A1434	Nut—Wing, Cad. plated, 5/16-24NF-2 (com'l)	1
16	43A1396	Lock—Cap Screw	1
21	43A1431	Washer—Lock, Cad. plated, 5/16 (com'l)	1
22	43A1433	Washer—Flat. Cad. plated, 5/16 (com'l)	1
31	43C1391	CASE-CARRYING	1
32	43A1393	Clip—Level vial	1
33	43A1390	Plate—Name	1
34	43A1436	Pins—Escutcheon, Cad. plated, 1/4 lgth. (com'l)	2
	43C1392	CARTON—SHIPPING	1

* Part is procurable in assembly only.